Go beyond the textbook with Pearson Mathematics III

Pearson Integrated High School Mathematics III Common Core © 2014 provides teachers with a wealth of online resources uniquely suited for the needs of a diverse classroom. From extra practice to performance tasks, along with activities, games, and puzzles, Pearson is your one-stop shop for flexible Common Core teaching resources.

In this sampler, you will find all the online support available for select Mathematics III lessons from Chapter 6, illustrating the scope of resources available for the course. Pearson Mathematics III Teacher Resources help you help your students achieve success in mathematics!

Contents include:

- rigorous practice worksheets
- extension activities
- intervention and reteaching resources
- support for English Language Learners
- performance tasks
- activities and projects
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Think About a Plan

Geometry Show that the right triangle with legs of length $\sqrt{2} - 1$ and $\sqrt{2} + 1$ is similar to the right triangle with legs of length $6 - \sqrt{32}$ and 2.

Understanding the Problem

1. What is the length of the shortest leg of the first triangle? Explain.

2. What is the length of the shortest leg of the second triangle? Explain.

3. Which legs in the two triangles are corresponding legs?

Planning the Solution

4. Write a proportion that can be used to show that the two triangles are similar.

Getting an Answer

5. Simplify your proportion to show that the two triangles are similar.
Add or subtract if possible.

1. $9\sqrt{3} + 2\sqrt{3}$
2. $5\sqrt{2} + 2\sqrt{3}$
3. $3\sqrt{7} - 7\sqrt{x}$

4. $14\sqrt{xy} - 3\sqrt{xy}$
5. $8\sqrt{x} + 2\sqrt{y}$
6. $5\sqrt{xy} + \frac{\sqrt{xy}}{2}$

7. $\sqrt{3x} - 2\sqrt{3x}$
8. $6\sqrt{2} - 5\sqrt{2}$
9. $7\sqrt{x} + x\sqrt{7}$

Simplify.

10. $3\sqrt{32} + 2\sqrt{50}$
11. $\sqrt{200} - \sqrt{72}$
12. $\sqrt{81} - 3\sqrt{3}$

13. $2\sqrt{48} + 3\sqrt{243}$
14. $3\sqrt{75} + 2\sqrt{12}$
15. $\sqrt{250} - \sqrt{54}$

16. $\sqrt{28} - \sqrt{63}$
17. $3\sqrt{32} - 2\sqrt{162}$
18. $\sqrt{125} - 2\sqrt{20}$

Multiply.

19. $(1 - \sqrt{5})(2 - \sqrt{5})$
20. $(1 + 4\sqrt{10})(2 - \sqrt{10})$
21. $(1 - 3\sqrt{7})(4 - 3\sqrt{7})$

22. $(4 - 2\sqrt{3})^2$
23. $(\sqrt{2} + \sqrt{7})^2$
24. $(2\sqrt{3} - 3\sqrt{2})^2$

25. $(4 - \sqrt{3})(2 + \sqrt{3})$
26. $(3 + \sqrt{11})(4 - \sqrt{11})$
27. $(3\sqrt{2} - 2\sqrt{3})^2$

Multiply each pair of conjugates.

28. $(3\sqrt{2} - 9)(3\sqrt{2} + 9)$
29. $(1 - \sqrt{7})(1 + \sqrt{7})$

30. $(5\sqrt{3} + \sqrt{2})(5\sqrt{3} - \sqrt{2})$
31. $(3\sqrt{2} - 2\sqrt{3})(3\sqrt{2} + 2\sqrt{3})$

32. $(\sqrt{11} + 5)(\sqrt{11} - 5)$
33. $(2\sqrt{7} + 3\sqrt{3})(2\sqrt{7} - 3\sqrt{3})$
Rationalize each denominator. Simplify the answer.

34. \( \frac{3 - \sqrt{10}}{\sqrt{5} - \sqrt{2}} \)

35. \( \frac{2 + \sqrt{14}}{\sqrt{7} + \sqrt{2}} \)

36. \( \frac{2 + \sqrt{x}}{\sqrt{x}} \)

Simplify. Assume that all the variables are positive.

37. \( \sqrt{28} + 4\sqrt{63} - 2\sqrt{7} \)

38. \( 6\sqrt{40} - 2\sqrt{90} - 3\sqrt{160} \)

39. \( 3\sqrt{12} + 7\sqrt{75} - \sqrt{54} \)

40. \( 4\sqrt{81} + 2\sqrt{72} - 3\sqrt{24} \)

41. \( 3\sqrt{225x} + 5\sqrt{144x} \)

42. \( 6\sqrt{45y^2} + 4\sqrt{20y^2} \)

43. \( (\sqrt{y} - \sqrt{5})(2\sqrt{y} + 5\sqrt{5}) \)

44. \( (\sqrt{x} - \sqrt{3})(\sqrt{x} + \sqrt{3}) \)

45. A park in the shape of a triangle has a sidewalk dividing it into two parts.

a. If a man walks around the perimeter of the park, how far will he walk?

b. What is the area of the park?

46. The area of a rectangle is 10 in. \(^2\). The length is \((2 + \sqrt{2})\) in. What is the width?

47. One solution to the equation \( x^2 + 2x - 2 = 0 \) is \(-1 + \sqrt{3}\). To show this,

let \( x = -1 + \sqrt{3} \) and answer each of the following questions.

a. What is \( x^2 \)?

b. What is \( 2x \)?

c. Using your answers to parts (a) and (b), what is the sum \( x^2 + 2x - 2 \)?
Simplify if possible. To start, determine if the expressions contain like radicals.

1. \(\sqrt[3]{5} + 4\sqrt[3]{5}\)  
2. \(8\sqrt[4]{4} - 6\sqrt[4]{4}\)  
3. \(2\sqrt[xy]{y} + 2\sqrt[3]{y}\)  
   both radicals

4. A floor tile is made up of smaller squares. Each square measures 3 in. on each side. Find the perimeter of the floor tile.

Simplify. To start, factor each radicand.

5. \(\sqrt{18} + \sqrt{32}\)  
6. \(\sqrt[4]{324} - \sqrt[4]{2500}\)  
7. \(\sqrt[3]{192} + \sqrt[3]{24}\)  
   \(= \sqrt{9}\cdot2 + \sqrt{16}\cdot2\)

Multiply.

8. \((3 - \sqrt{6})(2 - \sqrt{6})\)  
9. \((5 + \sqrt{5})(1 - \sqrt{5})\)  
10. \((4 + 7)^3\)

Multiply each pair of conjugates.

11. \((7 - \sqrt{2})(7 + \sqrt{2})\)  
12. \((1 + 3\sqrt{3})(1 - 3\sqrt{3})\)  
13. \((6 + 4\sqrt{7})(6 - 4\sqrt{7})\)
Rationalize each denominator. Simplify the answer.

14. \[ \frac{3}{2 + \sqrt{6}} \]
   \[ = \frac{3}{2 + \sqrt{6}} \cdot \frac{2 - \sqrt{6}}{2 - \sqrt{6}} \]

15. \[ \frac{7 + \sqrt{5}}{6 - \sqrt{5}} \]
   \[ = \frac{7 + \sqrt{5}}{6 - \sqrt{5}} \cdot \frac{6 + \sqrt{5}}{6 + \sqrt{5}} \]

16. \[ \frac{1 - 2\sqrt{10}}{4 + \sqrt{10}} \]
   \[ = \frac{1 - 2\sqrt{10}}{4 + \sqrt{10}} \cdot \frac{4 - \sqrt{10}}{4 - \sqrt{10}} \]

17. A section of mosaic tile wall has the design shown at the right. The design is made up of equilateral triangles. Each side of the large triangle is 4 in. and each side of a small triangle is 2 in. Find the total area of the design to the nearest tenth of an inch.

18. \[ \sqrt{45} - \sqrt{80} + \sqrt{245} \]
19. \[ (2 - \sqrt{98})(3 + \sqrt{18}) \]
20. \[ 6\sqrt{192xy^2} + 4\sqrt{3xy^2} \]

21. Error Analysis A classmate simplified the expression \[ \frac{1}{1 - \sqrt{2}} \] using the steps shown.
   What mistake did your classmate make? What is the correct answer?

\[
\begin{align*}
\frac{1}{1 - \sqrt{2}} & \cdot \frac{1 + \sqrt{2}}{1 + \sqrt{2}} \\
\frac{1 - \sqrt{2}}{1 - 2} & = \frac{1 - \sqrt{2}}{-1} \\
& = -1 + \sqrt{2}
\end{align*}
\]

22. Writing Explain the first step in simplifying \[ \sqrt{405} + \sqrt{80} - \sqrt{5} \].
Multiple Choice

For Exercises 1–5, choose the correct letter.

1. What is the simplest form of $2\sqrt{72} - 3\sqrt{32}$?
   -A- $2\sqrt{72} - 3\sqrt{32}$  -B- $24\sqrt{2}$  -C- $-2\sqrt{2}$  -D- $0$

2. What is the simplest form of $(2 - \sqrt{7})(1 + 2\sqrt{7})$?
   -E- $-12 + 3\sqrt{7}$  -F- $16 + 5\sqrt{7}$  -G- $-12 - 3\sqrt{7}$  -H- $3 + \sqrt{7}$

3. What is the simplest form of $(\sqrt{2} + \sqrt{7})(\sqrt{2} - \sqrt{7})$?
   -A- $9 + 2\sqrt{14}$  -B- $9 - 2\sqrt{14}$  -C- $-5$  -D- $9$

4. What is the simplest form of $\frac{7}{2 + \sqrt{5}}$?
   -E- $-14 + 7\sqrt{5}$  -F- $14 - 7\sqrt{5}$  -G- $14 + 7\sqrt{5}$  -H- $-14 - 7\sqrt{5}$

5. What is the simplest form of $8\sqrt{5} - \sqrt{40} - 2\sqrt{135}$?
   -A- $16\sqrt{5}$  -B- $12\sqrt{5}$  -C- $4\sqrt{5}$  -D- $0$

Short Response

6. A hiker drops a rock from the rim of the Grand Canyon. The distance it falls $d$ in feet after $t$ seconds is given by the function $d = 16t^2$. How far has the rock fallen after $(3 + \sqrt{2})$ seconds? Show your work.
Two radical expressions are *like radicals* if they have the same index and the same radicand.

Compare radical expressions to the terms in a polynomial expression.

Like terms: \[4x^3 \quad 11x^3\] The power and the variable are the same

Unlike terms: \[4y^3 \quad 11x^3 \quad 4y^2\] Either the power or the variable are not the same.

Like radicals: \[\sqrt{3} \quad 6 \quad \sqrt{5} \quad 3 \quad \sqrt{6}\] The index and the radicand are the same

Unlike radicals: \[\sqrt{4} \quad 5 \quad \sqrt{11} \quad 6 \quad 4\sqrt{2} \sqrt{6}\] Either the index or the radicand are not the same.

When adding or subtracting radical expressions, simplify each radical so that you can find like radicals.

**Problem**
What is the sum? \[\sqrt{63} + \sqrt{28}\]

\[
\sqrt{63} + \sqrt{28} = \sqrt{9 \cdot 7} + \sqrt{4 \cdot 7} \\
= \sqrt{3^2 \cdot 7} + \sqrt{2^2 \cdot 7} \\
= 3\sqrt{7} + 2\sqrt{7} \\
= 5\sqrt{7}
\]

The sum is \[5\sqrt{7}\].

**Exercises**

Simplify.

1. \[\sqrt{150} - \sqrt{24}\]  
2. \[\sqrt[3]{135} + \sqrt[3]{40}\]  
3. \[6\sqrt{3} - \sqrt{75}\]  
4. \[5\sqrt{2} - \sqrt{54}\]  
5. \[-\sqrt{48} + \sqrt{147} - \sqrt{27}\]  
6. \[8\sqrt[3]{3x} - \frac{2}{3} \sqrt[3]{24x} + \frac{2}{3} \sqrt[3]{192x}\]
• Conjugates, such as \( \sqrt{a} + \sqrt{b} \) and \( \sqrt{a} - \sqrt{b} \), differ only in the sign of the second term. If \( a \) and \( b \) are rational numbers, then the product of conjugates produce a rational number:
\[
(\sqrt{a} + \sqrt{b})(\sqrt{a} - \sqrt{b}) = (\sqrt{a})^2 - (\sqrt{b})^2 = a - b
\]
• You can use the conjugate of a radical denominator to rationalize the denominator.

**Problem**

What is the product? \( (2\sqrt{7} - \sqrt{5})(2\sqrt{7} + \sqrt{5}) \)

\[
(2\sqrt{7} - \sqrt{5})(2\sqrt{7} + \sqrt{5}) \quad \text{These are conjugates.}
\]
\[
= (2\sqrt{7})^2 - (\sqrt{5})^2 \quad \text{Use the difference of squares formula.}
\]
\[
= 28 - 5 = 23 \quad \text{Simplify.}
\]

**Problem**

How can you write the expression with a rationalized denominator? \( \frac{4\sqrt{2}}{1 + \sqrt{3}} \)

\[
\frac{4\sqrt{2}}{1 + \sqrt{3}} = \frac{4\sqrt{2} - 4\sqrt{6}}{1 - 3} \quad \text{Multiply.}
\]
\[
= \frac{4\sqrt{2} - 4\sqrt{6}}{2} = \frac{(4\sqrt{2} - 4\sqrt{6})}{2} \quad \text{Simplify.}
\]
\[
= -4\sqrt{2} + 4\sqrt{6} = -2\sqrt{2} + 2\sqrt{6}
\]

**Exercises**

Simplify. Rationalize all denominators.

7. \( (3 + \sqrt{6})(3 - \sqrt{6}) \)  
8. \( \frac{2\sqrt{3} + 1}{5 - \sqrt{3}} \)  
9. \( (4\sqrt{6} - 1)(\sqrt{6} + 4) \)  
10. \( \frac{2 - \sqrt{7}}{2 + \sqrt{7}} \)  
11. \( (2\sqrt{8} - 6)(\sqrt{8} - 4) \)  
12. \( \frac{\sqrt{5}}{2 + \sqrt{3}} \)
The column on the left shows the steps used to rationalize a denominator. Use the column on the left to answer each question in the column on the right.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Rationalizing the Denominator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write the expression ( \frac{4\sqrt{3}}{\sqrt{7} + \sqrt{3}} ) with a rationalized denominator.</td>
<td></td>
</tr>
<tr>
<td>Multiply the numerator and the denominator by the conjugate of the denominator.</td>
<td></td>
</tr>
<tr>
<td>( \frac{4\sqrt{3}}{\sqrt{7} + \sqrt{3}} \cdot \frac{\sqrt{7} - \sqrt{3}}{\sqrt{7} - \sqrt{3}} )</td>
<td></td>
</tr>
<tr>
<td>The radicals in the denominator cancel out.</td>
<td></td>
</tr>
<tr>
<td>( \frac{4\sqrt{3}(\sqrt{7} - \sqrt{3})}{7 - 3} )</td>
<td></td>
</tr>
<tr>
<td>Distribute ( \sqrt{3} ) in the numerator.</td>
<td></td>
</tr>
<tr>
<td>( \frac{4(\sqrt{3} \cdot \sqrt{7} - \sqrt{3} \cdot \sqrt{3})}{7 - 3} )</td>
<td></td>
</tr>
<tr>
<td>Simplify.</td>
<td></td>
</tr>
<tr>
<td>( \frac{4(\sqrt{21} - 3)}{4} )</td>
<td></td>
</tr>
<tr>
<td>Simplify.</td>
<td></td>
</tr>
<tr>
<td>( \sqrt{21} - 3 )</td>
<td></td>
</tr>
</tbody>
</table>

1. What does it mean to rationalize a denominator? |

2. What are conjugates? |

3. Write and solve an equation to show why the radicals in the denominator cancel out. |

4. What property allows you to distribute the \( \sqrt{3} \)? |

5. Why do the fours in the numerator and the denominator cancel out? |

6. What number multiplied by \( \sqrt{21} \) would produce a product of 21? |
Form five teams for this activity.

Each team will investigate one of the expressions shown below. Notice that each of the expressions has the general form $a + b\sqrt{p}$ where $a$ and $b$ are real numbers and $p$ is a prime number. Are numbers of this form closed under multiplication? Let’s find out.

<table>
<thead>
<tr>
<th>Team A</th>
<th>Team B</th>
<th>Team C</th>
<th>Team D</th>
<th>Team E</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2 + \sqrt{2}$</td>
<td>$3 - \sqrt{3}$</td>
<td>$1 + 2\sqrt{5}$</td>
<td>$-1 + 2\sqrt{7}$</td>
<td>$2 + \sqrt{11}$</td>
</tr>
</tbody>
</table>

Complete the table below by raising your radical expression to the $1^{\text{st}}$, $2^{\text{nd}}$, and $3^{\text{rd}}$ power.

<table>
<thead>
<tr>
<th></th>
<th>Team A</th>
<th>Team B</th>
<th>Team C</th>
<th>Team D</th>
<th>Team E</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1^{\text{st}}$ power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2^{\text{nd}}$ power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$3^{\text{rd}}$ power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Look at the answers in your column. What do you notice about the general form of each of them?

2. Raise your radical expression to the fourth and fifth powers using the space below. What do you notice about the general form of your answers?

3. If you were to raise $1 + 2\sqrt{3}$ to the fifth power, what can you predict about the general form of the answer?

4. Which property is illustrated by your answers to Exercises 1–3? Explain.

Discuss your findings as a class to see if each of the five teams came to the same conclusion.
Provide the host with the following questions and answers. The answers to the questions in the table on the left are underlined.

<table>
<thead>
<tr>
<th>The Greater Exponent?</th>
<th>A</th>
<th>B</th>
<th>Positive or Negative?</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( \sqrt[3]{x^3} ) or ( (x^3)^{\frac{1}{3}} )</td>
<td></td>
<td></td>
<td>1. ( -32 ) Answer: N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ( x^3 ) or ( (x^3)^{\frac{1}{3}} )</td>
<td>( \sqrt{3} )</td>
<td>( 5 )</td>
<td>2. ( 32 ) ( \frac{6}{5} ) Answer: P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. ( x^3 ) or ( (x^3)^{\frac{1}{3}} )</td>
<td>( \sqrt{3} )</td>
<td>( 5 )</td>
<td>3. ( 27 ) ( \frac{2}{3} ) Answer: N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ( x^3 ) or ( (x^3)^{\frac{1}{3}} )</td>
<td>( \sqrt{3} )</td>
<td>( 5 )</td>
<td>4. ( 27 ) ( \frac{1}{3} ) Answer: P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ( \sqrt[10]{x^{10}} ) or ( x^{\frac{1}{5}} )</td>
<td>( \sqrt[10]{10} )</td>
<td>( 5 )</td>
<td>5. ( 16 ) ( \frac{1}{3} ) Answer: N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ( x^3 ) or ( (x^3)^{\frac{1}{3}} )</td>
<td>( \sqrt{3} )</td>
<td>( 5 )</td>
<td>6. ( 4^{\frac{1}{4}} ) Answer: P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. ( x^{20} ) or ( (x^{20})^{\frac{1}{5}} )</td>
<td>( \sqrt[10]{20} )</td>
<td>( 5 )</td>
<td>7. ( \sqrt[3]{125} ) ( \frac{2}{3} ) Answer: P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. ( \sqrt[4]{x^3} ) or ( x^{\frac{3}{4}} )</td>
<td>( \sqrt[4]{3} )</td>
<td>( 5 )</td>
<td>8. ( \sqrt{32} ) Answer: N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. ( x^3 ) or ( (x^3)^{\frac{1}{3}} )</td>
<td>( \sqrt{3} )</td>
<td>( 5 )</td>
<td>9. ( \sqrt[3]{24} ) ( \frac{2}{3} ) Answer: N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. ( x^3 ) or ( (x^3)^{\frac{1}{3}} )</td>
<td>( \sqrt{3} )</td>
<td>( 5 )</td>
<td>10. ( \sqrt[3]{-2} ) ( \frac{2}{3} ) Answer: N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Game: A Rational Quiz

This is a game for three students. Decide on a host and two players.
• The host will take turns asking each player a question from the left column of the table.
• The player determines which expression (when simplified) has the greater exponent, underlines the expression, and states the answer.
• All correct answers are worth 3 points.

Then the host will take turns giving each player a question from the right column of the table.
• The player determines whether the expression is positive or negative, writes either “P” or “N”, and states the answer.
• The host will keep score and announce the winner at the end of the game.

<table>
<thead>
<tr>
<th>The Greater Exponent?</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ((\sqrt[2]{X^3})^2) or ((X^2)^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ((\sqrt[6]{X^2})^2) or ((X^4)^{\frac{1}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. ((\sqrt[3]{X^2})^3) or ((X^2)^{\frac{3}{2}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ((\sqrt[3]{X^2})^3) or ((X^{1.5})^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ((\sqrt[10]{X^{1.5}})^{0.5}) or ((X^{1.5})^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ((\sqrt[2.5]{X^2})^2) or ((X^3)^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. ((\sqrt[4.5]{X^{21}})^{4.5}) or ((X^{20})^{\frac{1}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. ((\sqrt[43]{X^7})^{43}) or ((X^9)^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. ((\sqrt[6]{X^6})^6) or ((X^4)^{\frac{8}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. ((\sqrt[2.5]{X^9})^2.5) or ((X^3)^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Positive or Negative?</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (-32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ((-32)^{\frac{6}{5}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. (-27^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. (-27^{\frac{1}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. (-16^{\frac{1}{4}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ((-64)^{\frac{1}{4}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. ((\sqrt[3]{125})^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. (-16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. (-24^{\frac{2}{3}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. (-4^{\frac{2}{2}})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Puzzle: A Radical Solution

You have solved equations that involve square roots of algebraic expressions. Then you checked your solutions to see if they are actual solutions or extraneous solutions.

To find the answer to the question at the bottom of the page:

- Solve each equation. Use the space below to show your work.
- Write solutions below each equation. Identify any extraneous solutions.
- Use only the actual solutions that are positive integers to answer the question.

\[ x = \sqrt{4x - 2} \quad x = \sqrt{3 - 2x} \]

\[ x = \sqrt{-2x + 48} \quad x = \sqrt{90 - x} \]

\[ x = \sqrt{117 - 4x} \quad x = \sqrt{6x - 3} \]

\[ x = \sqrt{2x + 1} \quad x = \sqrt{x + 72} \]

Actual solutions that are positive integers: ________________________________

Question: In what year did the first astronaut land on the moon?

The first astronaut landed on the moon in ______________.
Consider how you might use a calculator to find the square of negative three. If you enter the expression \(-3^2\), your calculator produces an answer of \(-9\). However, the square of negative three is \((-3)^2 = (-3)(-3) = 9\). Calculators follow the order of operations. Therefore, a calculator will compute \(-3^2\) as the opposite of \(3^2\). The correct input is \((-3)^2\), which is correctly evaluated as 9. Be sure to follow the order of operations when expanding binomial radical expressions.

1. Consider the algebraic expression \((a + b)^2\). Is \((a + b)^2\) equivalent to \(a^2 + b^2\)? If yes, explain. If not, explain why it is not mathematically logical and give a counterexample.

2. Are there values of \(a\) and \(b\) for which \((a + b)^2 = a^2 + b^2\)?

Consider each pair of expressions below for nonnegative values of the variables. State whether they are equivalent expressions. If yes, explain. If not, give a counterexample.

3. \(\sqrt{x^2 + y^2}, \sqrt{x^2} + \sqrt{y^2}\)

4. \(\frac{\sqrt{a}}{b}, \frac{\sqrt{a}}{b}\)

5. \((\sqrt{a})^2, a\)

6. \((\sqrt{x^2 + y^2})^2, x + y\)
Radical Translations I

In the “Quadratic Translations II” Activity, you studied translations of the quadratic function, building from the parent function $y = x^2$ to a general form that you can write as $y = a(x - b)^2 + c$.

In this activity you will study translations of the radical function, building from the parent function $y = \sqrt{x}$ to the general form $y = a\sqrt{x - b} + c$. You should notice that the two general forms are quite similar. It turns out that the effects of $a$, $b$, and $c$ on the graphs of the functions are quite similar as well.

A2L78A graphs the square root function $y = a\sqrt{x - b} + c$ as $Y1 = A(X - B) + C$.

1. Run A2L78A. Write the function equation for the graph shown in the startup window. What special name does this function have? Describe its domain and range.

2. Recall the effects of change in $c$ on the graph of $y = a(x - b)^2 + c$. Predict how change in $c$ will affect the graph of $y = a\sqrt{x - b} + c$.

3. Test your prediction. Change the value of $C$ in increments of 1. What happens to the graph? Use increments of $-1$. What happens to the graph?

4. Recall the effect of change in $b$ on the graph of $y = a(x - b)^2 + c$. Predict how change in $b$ will affect the graph of $y = a\sqrt{x - b} + c$.

5. Test your prediction. Set $C = 0$. Change the value of $B$ in increments of 1. What happens? In increments of $-1$. What happens?

6. For each given function, what are the values of $c$ and $b$? Describe the translation of the parent graph. Give the domain and range.
   a. $y = \sqrt{x} + 2$  b. $y = \sqrt{x} - 3$  c. $y = \sqrt{x - 3}$  d. $y = \sqrt{x} + 2$

7. For the function $y = \sqrt{x - 3} + 4$, describe two translations of the parent graph that result in the graph of this function. Give the domain and range. Use A2L78A to check your work.

8. Predict how changes in $a$ will affect the graph of $y = a\sqrt{x - b} + c$. Use A2L78A to change $A$ and check your predictions.

9. Shift the graph of $y = \sqrt{x}$ by 2 units down and 3 units left. What is the function equation for the new graph? Check using A2L78A.

10. Describe how the graph of each relates to the graph of $y = \sqrt{x}$.
   a. $y = 2\sqrt{x - 3} + 4$  b. $y = \frac{1}{2}\sqrt{x + 1} - 4$  c. $y = -4\sqrt{x + 3} + 6$
Radical Translations I

Activity Objective
Students use the Transformation Graphing App to explore how changing parameter values in the square root function $y = a \sqrt{x - b} + c$ affects the graph of the function.

Time
- 40–45 minutes

Materials/Software
- Transformation Graphing App
- Program: A2L78A
- Activity worksheet

Skills Needed
- change parameter values

Answers
1. $y = \sqrt{x}$; square root function; domain: $x \geq 0$, range: $y \geq 0$.
2. Moves the graph vertically by an amount equal to the change in $c$.
3. Moves up in steps of 1; moves down in steps of 1.
4. Moves the graph horizontally by an amount equal to the change in $b$.
5. Moves right in steps of 1; moves left in steps of 1.
6. a. $2, 0$; moves up 2 units; domain: $x \geq 0$, range: $y \geq 2$.
    b. $-3, 0$; moves down 3 units; domain: $x \geq 0$, range: $y \geq -3$.
    c. $0, 3$; moves right 3 units; domain: $x \geq 3$, range: $y \geq 0$.
    d. $0, -2$; moves left 2 units; domain: $x \geq -2$, range: $y \geq 0$.
7. Moves up 4 units and right 3 units; domain: $x \geq 3$, range: $y \geq 4$.
8. Increase in $a$ will stretch the graph vertically. Decrease in $a$ ($a > 0$) will shrink the graph vertically. A sign change in $a$ will reflect the graph across the line $y = c$.
9. $y = \sqrt{x} + 3 - 2$
10. For each of a–c, begin with the graph of $y = \sqrt{x}$.
    a. Shift right 5, stretch vertically by factor of 2, shift up 4.
    b. Shift left 1, shrink vertically by factor of $\frac{1}{2}$, shift down 4.
    c. Shift left 3, stretch vertically by factor of 4, reflect across $x$-axis, shift up 6.
In “Radical Translations I” you studied translations of the square root function, building from the parent function $y = \sqrt{x}$ to the general form $y = a\sqrt{x} - b + c$. You can take the general form further—to the $n$th-root function, $y = a\sqrt[n]{x} - b + c$.

**A2L78B** graphs the $n$th-root function using $Y1$, $Y2$, and $Y3$, as shown at the right.

1. For each of $Y1$, $Y2$, and $Y3$, complete the following using $a$, $b$, $c$, and $n$.

   - $y_1 = ?$
   - $y_2 = ?$
   - $y_3 = ?$

2. Run A2L78B. The startup screen shows the parent function $y = \sqrt{x}$. (Why?) Change the index $D$ (or $n$). Write equations for the parent functions you see for $D = 3, 4, 5, \ldots$. Describe any pattern you see in the sequence of displayed graphs.

3. Graphs of quadratic and absolute value functions have a vertex that you can use as a central point for describing translations. What point can you use as the central translation point for a parent radical function whose index is an odd number? An even number?

4. What are the domain and range of the parent $n$th-root function $y = \sqrt[n]{x}$ when $n$ is even? When $n$ is odd?

5. As you might suspect, the effects of $a$, $b$, and $c$ on the graphs of $y = a\sqrt[x]{x} - b + c$ and $y = a\sqrt[n]{x} - b + c$ are the same. Use what you know about the square root function to predict how the graph of the parent cube root function translates to the graph of each function given below.

   - a. $y = \sqrt[3]{x} - 3 + 1$
   - b. $y = \sqrt[3]{x} + 1 - 2$
   - c. $y = -\sqrt[3]{x} + 2$

   Use A2L78B to test your predictions. In the Y= window (see top of page), select $Y2$ by highlighting its “=” sign. Then press [GRAPH].

6. For each function below, list the domain and range, and sketch a graph. Use $Y2$ and $Y3$ in A2L78B to check your sketches.

   - a. $y = \sqrt[3]{x} + 5 - 2$
   - b. $y = \sqrt[3]{x} + 3$
   - c. $y = -\sqrt[3]{x} + 2 + 3$
   - d. $y = 2\sqrt[3]{x} + 3$
Radical Translations II

Activity Objective
Students use the Transformation Graphing App to study the effect of $n$ on the graphs of the parent radical function $y = \sqrt[n]{x}$, and to explore how changing other parameter values in $y = a\sqrt[n]{x} - b + c$ affects the graph of the function.

Time
• 40–45 minutes

Materials/Software
• Transformation Graphing App
• Program: A2L788
• Activity worksheet

Skills Needed
• change parameter values

Classroom Management
• Students can work individually or in pairs depending on the number of calculators available.

Answers
1. $y_1 = \sqrt[n]{x}; y_2 = a\sqrt[n]{x} - b + c; y_3 = a\sqrt[n]{x} - b + c$
2. $y = \sqrt[3]{x}, y = \sqrt{\sqrt[5]{x}}, y = \sqrt[n]{x}, \ldots$; Answers may vary. Sample: When $n$ is odd, the graphs of $y = \sqrt[n]{x}$ show similar behavior in Quadrants I and III. When $n$ is even, the graphs show similar behavior in Quadrant I and don’t appear anywhere else.
3. $(0, 0); (0, 0)$
4. nonnegative real numbers; real numbers
5. a. Translates right 3 and up 1.
   b. Translates left 1 and down 2.
   c. Reflects across the $x$-axis and translates up 2.
6. a. domain: reals; range: reals; graph: translate $y = \sqrt[3]{x}$ by 5 units left and 2 units down.
   b. domain: $x \geq 0$; range: $y \geq 3$; graph: translate $y = \sqrt[3]{x}$ by 3 units up.
   c. domain: reals; range: reals; graph: translate $y = \sqrt[3]{x}$ by 2 units left, reflect across the $x$-axis, and translate 3 units up.
   d. domain: $x \geq -3$; range: $y \geq 0$; graph: translate $y = \sqrt[3]{x}$ by 3 units left and stretch vertically by a factor of 2.
Lesson Quiz

Inverse Relations and Functions

1. What is the inverse of the relation described by
   \( y = 2x^2 + 7 \)?

2. Consider the function \( h(x) = 4\sqrt{x + 3} \).
   a. Find the domain and range of \( h \).
   b. What is the inverse of \( h \)?
   c. Find the domain and range of \( h^{-1} \).
   d. Is \( h^{-1} \) a function? Explain.

4. Do you UNDERSTAND? The formula for converting
temperatures from degrees Fahrenheit \( F \) to degrees
Celsius \( C \) is \( C = \frac{5}{9}(F - 32) \). What is the inverse function?
What is the temperature in Fahrenheit when it is
12 degrees Celsius?

5. Let \( k(x) = \frac{2}{x-1} \). What is each of the following?
   a. \( k^{-1}(x) \)
   b. \( (k \circ k^{-1})(1) \)
   c. \( (k^{-1} \circ k)(1) \)
Chapter 6 Quiz 1

Do you know HOW?

Find all the real roots.

1. \( \sqrt{36} \)  
2. \( \sqrt{0.25} \)  
3. \( \sqrt[3]{-64} \)  
4. \( \sqrt[4]{\frac{8}{125}} \)

Simplify each radical expression. Use absolute value symbols when needed.

5. \( \sqrt{25y^2} \)  
6. \( \sqrt[4]{49x^4} \)  
7. \( \sqrt[3]{-8x^6} \)  
8. \( \sqrt[3]{-0.125y^6} \)

Find the two real solutions of each equation.

9. \( 9x^2 - 4 = 0 \)
10. \( x^4 = 0.0016 \)

Multiply or divide and simplify. Assume that all variables are positive.

11. \( \sqrt{2x} \cdot \sqrt{18xy^2} \)
12. \( \frac{\sqrt{4xy^7}}{\sqrt[3]{32x^4y^4}} \)

Simplify. Rationalize all denominators.

13. \( \sqrt[3]{180} + \sqrt[3]{45} - 8\sqrt[3]{20} \)
14. \( \frac{5 + \sqrt{3}}{2 - \sqrt{3}} \)

Simplify each expression.

15. \( (-125)^\frac{2}{3} \)
16. \( 81^{\frac{3}{4}} \)
17. \( 32^{0.6} \)
18. \( 49^{1.5} \)

Do you UNDERSTAND?

19. Geometry  What is the perimeter of the triangle at the right?

20. Reasoning  Solve. \( \sqrt{75} + \sqrt{3x} = 12\sqrt{3} \)

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Chapter 6 Quiz 1

Do you know HOW?

Find each real root.
1. \( \sqrt{49} \)
2. \( \sqrt{0.36} \)
3. \( \sqrt[3]{-125} \)

Simplify. Assume that all variables are positive.
4. \( \sqrt[6]{600x^4y^3} \)
5. \( \sqrt[5]{54xy^5} \)
6. \( \sqrt[8]{64x^4y^8} \)

Divide and simplify.
7. \( \frac{\sqrt[5]{20x^3}}{\sqrt[5]{5x}} \)
8. \( \frac{\sqrt[7]{56x^4y}}{\sqrt[7]{7x^3y}} \)
9. \( \frac{\sqrt[4]{32a^5b^2}}{\sqrt[4]{2a^3b}} \)

Simplify.
10. \( \sqrt{7} + 3\sqrt{7} \)
11. \( \sqrt{18} + \sqrt{32} \)
12. \( 2\sqrt{24} - \sqrt{81} \)

Write each expression in radical form.
13. \( x^\frac{1}{3} \)
14. \( x^\frac{3}{2} \)
15. \( x^{1.5} \)

Write each expression in exponential form.
16. \( \sqrt[4]{4x^2} \)
17. \( \sqrt[5]{5ab} \)
18. \( \sqrt[6]{65x^4y} \)

Do you UNDERSTAND?

19. **Writing** Explain when absolute value symbols are needed when you are simplifying radical expressions.

20. An object is moving at a speed of \( |5 - \sqrt{3}| \) mi/h. How long will it take the object to travel 35 mi?
Do you know HOW?

Simplify each radical expression. Use absolute value symbols when needed.

1. $\sqrt{400x^2y^6}$
2. $\sqrt[3]{-125a^5}$
3. $\sqrt[3]{81x^3}y^9$
4. $\sqrt[4]{64a^6b^2}$
5. $\sqrt{50s^3t^4}$
6. $\sqrt{256x^6y^{28}}$

Simplify each expression. Rationalize all denominators. Assume that all variables are positive.

7. $\frac{\sqrt{200x^3y}}{\sqrt{2xy^3}}$
8. $(8 - 3\sqrt{2})(8 + 3\sqrt{2})$
9. $\frac{1}{\sqrt{3} + 5}$
10. $\sqrt{8x^5} \cdot \sqrt{2x^3}$
11. $\sqrt{63 + 2\sqrt{28} - 5\sqrt{7}}$
12. $\frac{\sqrt{2} + 1}{\sqrt{4}}$
13. $\frac{2}{1 + \sqrt{2}}$
14. $\frac{\sqrt{5}}{\sqrt{4}}$
15. $\sqrt{15(1 - \sqrt{45})}$

Simplify each expression. Assume that all variables are positive.

16. $\left(\frac{16\sqrt{x^{10}}}{81xy^2}\right)^{\frac{3}{4}}$
17. $(-64)^{\frac{2}{3}}$
18. $a^{\frac{2}{3}} \cdot a^{\frac{1}{2}}$
19. $(4x^{-2}y^4)^{-\frac{1}{2}}$
20. $(8ab^3)^{\frac{1}{2}}(8ab^3)^{\frac{1}{2}}$
21. $\left(\frac{2}{s^2t^3}\right)^{\frac{1}{2}}\left(\frac{1}{s^2t^2}\right)^{\frac{1}{2}}$

Solve each equation. Check for extraneous solutions.

22. $\sqrt{x - 3} = 1$
23. $\sqrt{x + 7} = x + 1$
24. $\sqrt{3x - 8} = 2$
25. $(2x + 1)^{\frac{1}{3}} = 3$
26. $\sqrt{x^2 - 5} = 4$
27. $3(x + 1)^{\frac{4}{3}} = 48$

Let $f(x) = x^2 + 5$ and $g(x) = x - 7$. Perform each function operation and then find the domain.

28. $\frac{f(x)}{g(x)}$
29. $f(x) - 2g(x)$
30. $f(x) \cdot g(x)$

For each pair of functions, find $(f \cdot g)(x)$ and $(g \cdot f)(x)$.

31. $f(x) = 3x + 5, g(x) = x^2 + 1$
32. $f(x) = x^2 - 5x + 2, g(x) = 2x$
33. $f(x) = \sqrt{2x - 1}, g(x) = 5x + 3$
34. $f(x) = -2x^2, g(x) = x + 4$

Let $f(x) = 5x - 4$ and $g(x) = x^3 - 1$. Find each value.

35. $(g \cdot f)(-1)$
36. $(f \cdot g)(2)$
37. $(g \cdot f)(0)$
38. $f(g(\sqrt{6}))$
39. $f(g(0))$
40. $g\left(\frac{4}{5}\right)$
Chapter 6 Test (continued)  

Find the inverse of each function. Is the inverse a function?

41. \( f(x) = (x + 2)^2 - 4 \)  
42. \( f(x) = 4x^3 - 1 \)  
43. \( f(x) = \sqrt{x + 4} \)  
44. \( f(x) = 3x + 2 \)  
45. \( f(x) = x^2 - 5 \)  
46. \( f(x) = \sqrt[3]{x + 2} \)

Graph. Find the domain and range of each function.

47. \( y = \sqrt{x - 1} + 2 \)  
48. \( y = -\sqrt{x + 3} - 1 \)  
49. \( y = \frac{1}{2}\sqrt{x + 3} \)  
50. \( y = -\sqrt{x + 4} - 1 \)

Rewrite each function to make it easy to graph using transformations. Describe the graph.

51. \( y = \sqrt{9x - 63} + 4 \)  
52. \( y = \sqrt{8x - 64} - 5 \)  
53. \( y = \sqrt{-27x - 27} + 4 \)  
54. \( y = \sqrt{16x - 32} \)

55. The children’s park has become very popular since your club built new play equipment.  
Use the equation \( f = 4\sqrt{A} \) to calculate the amount of fence \( f \) you need to buy based on the area \( A \) of the playground.  

a. The park currently has an area of 8100 ft\(^2\). How many feet of fencing currently encloses the park?  

b. Suppose you want to increase the fenced play area to four times its current area. If you can reuse the fencing already at the park, how much new fencing do you need to buy?

Do you UNDERSTAND?

56. Writing Explain under what circumstances \( -x^n = (-x)^n \) and provide an example to justify your answer.

57. Reasoning Graph \( y = \sqrt{x} \) and \( y = \sqrt[3]{x} \) on the same coordinate grid. Notice that for \( 0 < x < 1 \), the graph of \( y = \sqrt{x} \) lies below the graph of \( y = \sqrt[3]{x} \) but the opposite is true for \( x > 1 \). Explain why this is the case. Give an example.
Do you know HOW?
Simplify each radical expression. Use absolute value symbols when needed.
1. \(\sqrt{49x^2 y^{10}}\)  
2. \(\sqrt{-64 y^9}\)  
3. \(\sqrt[3]{243x^{15}}\)

Multiply and simplify.
4. \(\sqrt[3]{15} \times \sqrt[3]{18}\)  
5. \(\sqrt{7x^3} \cdot \sqrt{14x}\)  
6. \(\sqrt[3]{4x^3} \cdot \sqrt[3]{8x^4}\)

Rationalize each denominator. Simplify your answer.
7. \(\frac{1}{\sqrt{3}}\)  
8. \(\frac{\sqrt{x}}{\sqrt{5}}\)  
9. \(\frac{\sqrt[3]{4}}{\sqrt[2]{2x}}\)

Multiply.
10. \((7 + \sqrt{5})(1 + \sqrt{5})\)  
11. \((6 + \sqrt{10})^2\)  
12. \((5 + \sqrt{3})(2 - \sqrt{3})\)

Simplify each number.
13. \(27^{\frac{2}{3}}\)  
14. \(251.5\)  
15. \(2^{\frac{3}{4}}\)

Write each expression in simplest form.
16. \((\frac{x^2}{3})^{-2}\)  
17. \((\frac{3}{x^4})^{\frac{4}{3}}\)  
18. \((x^{\frac{3}{8}} y^{\frac{1}{2}})^{16}\)

Solve.
19. \(\sqrt{2x + 1} = 5\)  
20. \((x + 6)^{\frac{3}{2}} = 8\)  
21. \((x^2 + 13)^{\frac{1}{2}} = 7\)
Chapter 6 Test (continued)

Let \( f(x) = \sqrt{x} + 3 \) and \( g(x) = 4 - \sqrt{x} \). Perform each function operation and then find the domain.

22. \((f - g)(x)\)  
23. \((f \cdot g)(x)\)

Let \( f(x) = 3x + 1 \) and \( g(x) = x^2 + 2 \). Find each value or expression.

24. \((f \circ g)(2)\)  
25. \((g \circ f)(-3)\)

Graph each relation and its inverse.

26. \(y = x + 4\)  
27. \(y = x^2 - 2\)

Rewrite each function to make it easy to graph using transformations of its parent function. Describe the graph.

28. \(y = \sqrt{16x - 32}\)  
29. \(y = \sqrt[3]{8x} + 3\)

Do you UNDERSTAND?

30. Error Analysis Explain the error in this simplification of radical expressions.
What is the correct simplification? \(\sqrt{2} \cdot \sqrt[3]{8} = \sqrt{2(8)} = \sqrt{16} = 4\)

31. Reasoning Show that \(\sqrt[3]{x^3} = \sqrt{x}\) by rewriting \(\sqrt[3]{x^3}\) in exponential form.

32. A store is having a sale with a 15% discount on all items. In addition, employees get a $20 discount on purchases of $100 or greater. Will an employee get a better deal if the $20 discount is applied first or if the 15% discount is applied first to their purchase of $100?
Chapter 6 Performance Tasks

Give complete answers.

Task 1

a. Write a product of two square roots so that the answer, when simplified is $12x^3y^2$. Show how your product simplifies to give the correct answer.

b. Write a quotient of two cube roots so that the answer, when simplified, is $\frac{3a^2}{4b^3}$. Show how your quotient simplifies to give the correct answer.

c. Write a product of the form $(a + \sqrt{b})(a - \sqrt{b})$ so that the answer, when simplified, is 59. Show how your product simplifies to give the correct answer.

Task 2

a. Find a radical equation of the form $\sqrt{ax + b} = x + c$ so that one solution is extraneous. Show the steps in solving the equation.

b. Is there a value for $h$ that makes it possible for the equation $\sqrt{x + h} + 5 = 0$ to have any real number solutions? Explain.

c. Explain the relationship between the solutions to the equation $\sqrt{x - 3} - 2 = 0$ and the graph of the function $y = \sqrt{x - 3} - 2$. 

Let \( f(x) = x^2 + x - 12 \) and \( g(x) = x - 2 \). Answer each of the following questions.

**Task 3**

a. Find \( \frac{g(x)}{f(x)} \) and its domain. Explain how you determined the domain.

b. Find \((g \circ f)(x)\) and \((f \circ g)(x)\). Are they equal?

c. For what types of functions will \((g \circ f)(x)\) and \((f \circ g)(x)\) both equal \( x \)? Explain.

Give complete answers.

**Task 4**

a. Find the inverse of \( f(x) = \sqrt{x - 2} + 5 \). Show all steps in the process. What is the domain of \( f^{-1} \)?

b. Choose a value for \( a \) and use the inverse to find \((f \circ f^{-1})(a)\) and \((f^{-1} \circ f)(a)\) for the value you chose. What can you conclude about \((f \circ f^{-1})(a)\) and \((f^{-1} \circ f)(a)\)?

c. Graph \( f \) and \( f^{-1} \) on the same axes. What relationships do you see between the two graphs?
Chapter 6 Project Teacher Notes: Swing Time

About the Project
The Chapter Project gives students an opportunity to conduct experiments involving a real-world application of physics and mathematics. Students solve a formula for a given variable to write the formula in a more useful form, then use the formula to determine the periods of pendulums.

Introducing the Project
- Ask students if they have ever used a pendulum, or a swing-like motion. Remind them that the motion of a playground swing is similar to a pendulum’s motion.
- Have students speculate as to whether a homemade pendulum could continue to swing forever, or if it would eventually stop swinging. Encourage them to discuss what might cause a pendulum to stop swinging.

Activity 1: Constructing
Students use strings, coins, and binder clips to construct simple pendulums.

Activity 2: Investigating
Students perform experiments to time the swings of their pendulums and record their observations in charts.

Activity 3: Analyzing
Students solve a formula for a given variable, then use the formula to find the theoretical periods of their pendulums. They analyze their data and determine why their experimental results might differ from their theoretical results.

Finishing the Project
You may wish to plan a project day on which students share their completed projects. Encourage students to explain their processes as well as their results.
- Ask students to share their insights that resulted from completing the project, such as any shortcuts they found for using the formula or calculating the periods.

Chapter 6 Project: Swing Time

Beginning the Chapter Project

Galileo observed a swinging lantern and made an important discovery about the timing of a pendulum’s swing. A Dutch man named Christiaan Huygens discovered the relationship between the length of a pendulum and the time it takes to make a complete swing, which led to the use of pendulums in clock making.

You will construct pendulums using strings and weights and use your pendulums to investigate whether the length of the string or the amount of weight attached to a pendulum affects the time it takes the pendulum to make one full swing.

List of Materials

- Calculator
- Metric ruler or measuring tape
- Thread or thin string
- Binder clips (2 medium)
- Coins (3 quarters, 3 nickels, or 3 pennies)
- Stopwatch

Activities

Activity 1: Constructing

To construct a simple pendulum, tie a medium binder clip to the end of a piece of string. The binder clip will be used to hold one or more coins for the experiments in Activity 2. The weight on the end of the string, which includes the binder clip and the coin(s) it holds, is called the pendulum bob. The period of a pendulum is the time it takes for the pendulum to complete one full swing (back and forth).

Activity 2: Investigating

Experiment 1

Tie the free end of the string of the pendulum to a stable object. Do this in such a way that neither the string nor the bob touch another object when the pendulum is swung. Insert one coin in the binder clip. Measure the length of the string (in centimeters) from the point where it is attached to the stable object to the center of the bob. Record this length. Three times, pull the pendulum back to an angle of about 20° and let it go. For each trial, use a stopwatch to record the number of seconds it takes for the pendulum to complete 10 full swings. Record each time in the first column of the table provided on the next page. Next, find and record the average of the three times you listed. Finally, divide the average time by 10 to determine the period of the pendulum. Repeat the procedure using two coins, then using three coins, recording the data in the second and third columns, respectively. Does it appear that the weight of the bob affected the period of the pendulum? What factors other than the weight might affect the period of the pendulum?
Experiment 2

Cut a second string that is half the length of the original string. Repeat Experiment 1. Record data in a table. Does it appear that the pendulum string length affects its period? Explain.

Activity 3: Analyzing

The formula \( \ell = \frac{980t^2}{4\pi^2} \) represents the length \( \ell \) (in centimeters) of a simple pendulum with a period of \( t \) seconds. (In this formula, the acceleration due to gravity is given as 980 cm/s\(^2\).)

- Solve for \( t \). According to the formula, how does changing the weight of the bob affect the period of a pendulum?
- Use the formula to find the theoretical period for each pendulum. Record your experimental and theoretical periods for each.

<table>
<thead>
<tr>
<th>Length of Pendulum</th>
<th>Experimental Period</th>
<th>Theoretical Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do your experimental results give the same period as the theoretical models? What factors do you think would account for any differences? Explain your observations.

Finishing the Project

Prepare a presentation for the class describing your results. Your presentation should include a chart showing your experimental and theoretical results.

Reflect and Revise

When you are sure your data are accurate, decide if your presentation is complete, clear, and convincing. If needed, make changes to improve your presentation.

Extending the Project

Research the use of clock pendulums. Find out how a pendulum keeps time. Research periods of the pendulums used in different clock types.
Getting Started

Read the project. As you work on the project, you will need a calculator and materials on which you can record your results and make calculations. Keep all of your work for the project in a folder, along with this Project Manager.

Checklist
- Activity 1: constructing a pendulum
- Activity 2: determining the period
- Activity 3: comparing experimental and theoretical periods
- pendulum experiment

Suggestions
- Use the lightest thread or string possible.
- Have one student swing the pendulum while another student keeps time.
- Isolate \( t \), then take the square root of each side of the equation. Substitute the string lengths into the new equation.
- How would your results change if your pendulum were not able to swing freely, that is without contact with any other object? How would your results change if you pulled the pendulum back to an angle of 60°? What other changes would affect your results?

Scoring Rubric

4  Your experimental results are reasonable. Calculations are correct. Explanations are thorough and well thought out. Data, calculations, and conclusions are neatly presented.

3  Your experimental results are reasonable. Calculations are mostly correct with some minor errors. Explanations lack detail and accuracy. Data, calculations, and conclusions are not well organized.

2  Your experimental results are not reasonable. Calculations and explanations contain errors. Data, calculations, and conclusions are unorganized and lack detail.

1  Major concepts are misunderstood. Project satisfies few of the requirements and shows poor organization and effort.

0  Major elements of the project are incomplete or missing.

Your Evaluation of Project  Evaluate your work, based on the Scoring Rubric.

Teacher’s Evaluation of Project
OVERVIEW

<table>
<thead>
<tr>
<th>Looking Back</th>
<th>Mathematics of the Week</th>
<th>Looking Ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Chapter 3, students identified quadratic data (F.IF.6) and applied transformations to graphs of quadratic functions (F.BF.3).</td>
<td>Students use the binomial theorem to expand binomial expressions. They model data with polynomials and transform the graphs of polynomial functions.</td>
<td>In Chapter 7, students will explore applications and graphs of exponential and logarithmic functions (F.IF.7.e).</td>
</tr>
</tbody>
</table>

COMMON CORE MATHEMATICAL CONTENT STANDARDS

A.SSE.2 Use the structure of an expression . . . to rewrite it.

A.APR.5 Know and apply the Binomial Theorem for the expansion of \((x + y)^n\) . . . with coefficients determined for example by Pascal’s Triangle.

F.IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features . . .

F.IF.7.c Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.

F.IF.9 Compare properties of two functions each represented in a different way . . .

F.BF.3 Identify the effect on the graph of replacing \(f(x)\) by \(f(x) + k\), \(k f(x)\), \(f(kx)\), and \(f(x + k)\) for specific values of \(k\) . . . find the value of \(k\) given the graphs . . .

Common Core Mathematical Practice Standards: 1, 2, 4, 5, 6, 7, 8

Materials: Graphing Calculator

TEACHING NOTES

Selected Response
1. Error Analysis: Students use the Binomial Theorem to rewrite an expression. If the student answers A or B, he or she is confused on how to use the formula because \(x^2\) would be the third term of the expansion. If a student answers C, he or she chose the correct degree for the fourth term, but did not also multiply by \(3^3\).

Constructed Response
2. Students graph a cubic function and compare it to its parent function. To help students see how the functions compare, have students also graph \(y = \frac{4}{3}x^3\) and \(y = -\frac{4}{3}x^3\). Ask students how each of the graphs differ. Have students check their final graph with a graphing calculator.

Extended Response
3. Students use a set of data to find equations that fit the data and compare those equations. Suggest that students use a graphing calculator or computer software to make a scatter plot and to compare graphs for each of the functions. Remind students that the model whose regression coefficient \(r^2\) is closer to 1 is the best fit.
Selected Response

1. What is the fourth term of the binomial expansion of \((x + 3)^6\)?
   - A 15\(x^4\)
   - B 135\(x^4\)
   - C 20\(x^3\)
   - D 540\(x^3\)

Constructed Response

2. Graph the function \(f(x) = -\frac{4x^3}{3} + 2\) and its parent function in the same coordinate plane. Describe the transformation.

Extended Response

3. Consider the set of values \((-3, 34), (-2, 26), (-1, 18), (0, 7), (1, 15), (2, 21), (3, 27)\).
   - a. Find a linear model for the set of values.
   - b. Find a quadratic model for the set of values.
   - c. Find a cubic model for the set of values.
   - d. Use the regression coefficient of each model to determine which model best fits the set of values.
Performance Task: Modeling Ferris Wheel Rides

Complete this performance task in the space provided. Fully answer all parts of the performance task with detailed responses. You should provide sound mathematical reasoning to support your work.

You and your friend go to the county fair. There are two Ferris wheels there, like the ones shown below. For each Ferris wheel, riders travel 24 feet per minute along the wheel's circumference. The wheels are 2 ft above the ground.

Task Description
Assume that you start at the bottom of the larger wheel and your friend starts at the bottom of the smaller wheel at the same time. When will you and your friend be at the same height above the ground? How high will that be?

a. How long does the larger wheel take to complete 1 revolution? Round to the nearest hundredth of a minute.

b. Without calculating, how do you know that you and your friend will NOT reach the top of your wheels at the same time?
Performance Task: Modeling Ferris Wheel Rides (continued)

c. What is the period for the revolution of the smaller Ferris wheel? Round to the nearest hundredth of a minute.

d. Write functions to model the heights above the ground of you and your friend with respect to time.

e. Use a graphing calculator to graph the functions over the domain 0 to 7 minutes. Use the intersect or trace feature to determine when you and your friend will first be at the same height after the ride starts. What is this height?

f. Find the second time and height when you and your friend will be at the same height.

g. Use the graphs to estimate the times, between 0 and 7 minutes, when the difference between your heights will be the greatest.
Performance Task 2 Scoring Rubric

Modeling Ferris Wheel Rides

The Scoring Rubric proposes a maximum number of points for each of the parts that make up the Performance Task. The maximum number of points is based on the complexity and difficulty level of the sub-task. For some parts, you may decide to award partial credit to students who may have shown some understanding of the concepts assessed, but may not have responded fully or correctly to the question posed.

<table>
<thead>
<tr>
<th>Task Parts</th>
<th>Maximum Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Circumference of the larger wheel: $2\pi(20 \text{ ft}) = 40\pi \text{ ft}$</td>
<td>4</td>
</tr>
</tbody>
</table>

Since it is traveling at 24 feet per minute, the time it takes to complete 1 revolution is $40\pi / 24 = 5.23$ minutes.

<p>| | |</p>
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<thead>
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<tbody>
<tr>
<td>b. It will take more time to reach the top on the larger wheel, because the distance is greater and the speeds are equal.</td>
<td>2</td>
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</table>

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<tbody>
<tr>
<td>c. Circumference of the smaller wheel: $2\pi(16 \text{ ft}) = 32\pi \text{ ft}$</td>
<td>4</td>
</tr>
</tbody>
</table>

Since it is traveling at 24 feet per minute, the period for the revolution is $32\pi / 24 = 4.19$ minutes.

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<tbody>
<tr>
<td>d. Use a cosine function of the form $y = a \cos bx$, with $a = \text{amplitude}$, $\frac{2\pi}{b} = \text{period}$, and $x = \text{angle measure in radians}$. Then shift right and up.</td>
<td>4</td>
</tr>
</tbody>
</table>

You: $y = 20\cos\left(\frac{2\pi}{5.23}\left(x - \frac{5.23}{2}\right)\right) + 22.$

Your friend: $y = 16\cos\left(\frac{2\pi}{4.19}\left(x - \frac{4.19}{2}\right)\right) + 18.$

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<tbody>
<tr>
<td>e. The graphs first intersect at (1.72, 31.6); you will be at the same height after 1.72 minutes, and your height above the ground will be 31.6 feet.</td>
<td>2</td>
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<tbody>
<tr>
<td>f. The graphs intersect next at (4.68, 6.17); you will be at the same height again after 4.68 minutes, and your height above the ground will be 6.17 feet.</td>
<td>2</td>
</tr>
</tbody>
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<tbody>
<tr>
<td>g. The times when the difference between your heights will be greatest are close to 5.8 minutes after starting the ride.</td>
<td>2</td>
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<tbody>
<tr>
<td>Total points</td>
<td>20</td>
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</tbody>
</table>

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Common Core Readiness Assessment 2

1. Simplify the expression.
   \((x^4 + 3x^3 + x - 5) - (2x^4 - x^3 + 2x + 7)\)
   
   A \(-x^4 + 2x^3 - x + 2\)
   B \(3x^4 + 2x^3 + 3x + 2\)
   C \(-x^4 + 4x^3 - x - 12\)
   D \(3x^4 + 4x^3 + 3x - 12\)

2. Write the polynomial in factored form.
   \(2x^3 - 6x^2 + 4x\)
   
   F \(2x(x - 2)(x - 1)\)
   G \(2x(x + 2)(x - 1)\)
   H \(x(2x + 1)(x - 2)\)
   J \(x(2x + 1)(x + 2)\)

3. Which polynomial has zeros of 2, 5, and -4?
   
   A \((x + 2)(x + 5)(x - 4)\)
   B \((2x - 4)(x + 5)(x + 4)\)
   C \((x - 2)(x - 5)(x - 4)\)
   D \((2x - 4)(x - 5)(x + 4)\)

4. Write the polynomial in standard form with the zeros -4, 0, 3, and 3.
   
   F \(x^4 + 2x^3 - 13x^2 + 36x\)
   G \(x^4 - 2x^3 - 15x^2 + 36x\)
   H \(x^4 - 2x^3 + 15x^2 + 32x\)
   J \(x^4 - 3x^3 + 15x^2 - 32x\)

5. What are the solutions of \(3x^3 - 9x^2 - 12x = 0\)?
   
   A \(-4, -3, 1\)
   B \(-4, -1, 0\)
   C \(-1, 0, 4\)
   D \(0, 1, 4\)

6. Use the graph of the quadratic function \(f(x)\) to find the real solutions of \(f(x) = 0\).
   
   F \(3\)
   G \(0, 6\)
   H \(2, 4\)
   J no solution

7. What are the solutions of \(x^3 + 8 = 0\)?
   
   A \(-2, 2\)
   B \(-2, 1 + i\sqrt{3}, 1 - i\sqrt{3}\)
   C \(-2, 2, 1 + i\sqrt{3}, 1 - i\sqrt{3}\)
   D \(\sqrt{2}, \sqrt{4}, 2\)

8. Determine the end behavior of the graph of the polynomial function \(f(x) = x^4 + 3x^3 + 4x + 12\).
   
   F Up and Up
   G Down and Down
   H Down and Up
   J Up and Down
9. Use synthetic division and the remainder theorem to find \( P(a) \).
\[ P(x) = x^3 + 6x^2 - 7x - 60; \ a = 3 \]
A. -60
B. -3
C. 0
D. 3

10. What is the equation for the graph shown?
F. \( y = 1 - x^3 \)
G. \( y = x^3 - 1 \)
H. \( y = -x^3 - 1 \)
J. \( y = (x - 1)^3 \)

11. What is the average rate of change for the function \( f(x) = 4x^2 \) over the interval \( 0 \leq x \leq \frac{7}{4} \)?
A. 1.75
B. 3.0625
C. 7.0
D. 11.25

12. Which equation has the graph below?
F. \( y = \frac{5}{x+1} + 3 \)
G. \( y = \frac{5}{x-1} + 3 \)
H. \( y = \frac{3}{x+1} + 3 \)
J. \( y = \frac{3}{x-1} + 3 \)

13. Where will the discontinuities occur in the graph of the rational function?
\[ f(x) = \frac{3x - 4}{x^2 - 12x + 32} \]
A. at \( x = -8 \) and \( x = -4 \)
B. at \( x = 8 \) and \( x = 4 \)
C. at \( x = -\frac{8}{3} \) and \( x = 1 \)
D. at \( x = 3 \) and \( x = -4 \)

14. Which rational function has the most zeros in common with the function \( y = 2x + 6 \)?
F. \( y = \frac{3}{x-3} \)
G. \( y = \frac{5}{x^2 - 9} \)
H. \( y = \frac{x - 4}{2x - 6} \)
J. \( y = \frac{2x^2 - 18}{x - 3} \)
15. Multiply and simplify. \[
\frac{5x^2 + 25x}{x^2 + 2x} \cdot \frac{x^2 - 6x + 9}{30x^2}
\]
   A \(x + 3\) \\
   B \(\frac{x^4 + x^2}{6x}\) \\
   C \(\frac{x - 3}{6x}\) \\
   D none of the above

16. Divide and simplify. \[
\frac{2x}{5y^2} \div \frac{3x^3}{10y}
\]
   F \(\frac{3x^4}{25y^5}\) \\
   G \(\frac{20xy}{15x^2y^2}\) \\
   H \(3x^3y^2\) \\
   J \(\frac{4}{3x^2y}\)

17. Divide and simplify. \[
\frac{20x^3}{x^3(x^2 - 16)} \div \frac{4x^2}{x^2 - 8x + 16}
\]
   A \(\frac{5(x - 4)}{x^2(x + 4)}\) \\
   B \(\frac{5(x + 4)}{x^2(x - 4)}\) \\
   C \(\frac{5}{x^2}\) \\
   D \(\frac{(x - 4)}{x^2(x + 4)}\)

18. Subtract and simplify. \[
\frac{2}{4x} - \frac{3 - 2x}{x^2}
\]
   F \(\frac{-1 + 2x}{4x - x^2}\) \\
   G \(\frac{-1 + 2x}{4x^2}\) \\
   H \(\frac{5x - 6}{2x^2}\) \\
   J \(\frac{10x + 12}{4x^2}\)

19. Add and simplify. \[
\frac{2x}{x^2 - 36} + \frac{2}{5x + 30}
\]
   A \(\frac{12x - 12}{5(x + 6)}\) \\
   B \(\frac{3x - 3}{5(x + 6)(x - 6)}\) \\
   C \(\frac{12x + 12}{5(x + 6)}\) \\
   D \(\frac{12x - 12}{5(x + 6)(x - 6)}\)

20. Simplify the expression. \[
\frac{5}{x} + 2
\]
   F \(\frac{(5xy)(2xy)}{14xy}\) \\
   G \(\frac{5y + 2xy}{7x + 2xy}\) \\
   H \(\frac{7xy}{14xy}\) \\
   J \(\frac{5x + 7xy}{2y + 7xy}\)
21. At a banquet, 54 people will be seated at tables of the same size. The number of tables \( t \) varies inversely with the number \( n \) of people at each table. Which equation models this relationship?

A \( tn = 54 \)
B \( n = 54t \)
C \( t = 54n \)
D \( n = \frac{t}{54} \)

22. A pilot is planning to fly his plane on a round-trip to an airfield 300 miles west. There is a 20 mi/h wind blowing from the east. Write the round-trip time \( t \) as a function of the plane’s air speed \( r \).

F \( t(r) = 300(r + 20) + 300(r - 20) \)
G \( t(r) = \frac{300}{r^2 + 20} - 300(r - 20) \)
H \( t(r) = \frac{300}{r^2 + 20} \)
J \( t(r) = \frac{300}{r^2 + 20} + \frac{300}{r - 20} \)

23. Solve.

\[ \frac{4 + 3x}{x - 8} = \frac{7}{8 - x} \]

A \( -\frac{11}{3} \)
B \( 8, -\frac{11}{3} \)
C \( -\frac{13}{6} \)
D \( 25, -2 \)

24. Solve the equation for \( t \) and check the solution to determine whether it is an extraneous solution.

\[ \frac{4}{t - 5} + \frac{3}{t + 5} = \frac{40}{t^2 - 25} \]

F \( 3 \); solution
G \( 5 \); extraneous solution
H \( 3 \); extraneous solution
J \( 5 \); solution


\[ \sqrt{x + 14} - 2 = x \]

A \( x = 2 \) only
B \( x = -2 \) only
C \( x = -5 \) or \( x = 2 \)
D \( x = 5 \) or \( x = -2 \)

26. What is \( f^{-1} \), the inverse of \( f \), for the function \( f(x) = \sqrt{x - 5} \)?

F \( f^{-1}(x) = 5 - x^2 \), for \( x \geq 25 \)
G \( f^{-1}(x) = x^2 + 5 \), for \( x \geq 0 \)
H \( f^{-1}(x) = x^2 + 5 \), for \( x \geq -5 \)
J \( f^{-1}(x) = (x - 5)^2 \), for \( x \geq 0 \)
27. Solve. $\sqrt{6x - 18} - 9 = 0$
   A  6
   B  10.5
   C  16.5
   D  27

28. Simplify.
   $\sqrt{0.25x^2}$
   F  $0.5x^2$
   G  $-0.5x$ or $0.5x$
   H  $0.0625x$
   J  $-0.0625x^2$ or $0.0625x^2$

29. Simplify.
   $\sqrt[4]{x^{12}y^{16}}$
   A  $|x^3|y^4$
   B  $x^3y^4$
   C  $|x^3y^4|$
   D  $x^3|y^4|$

30. Simplify.
   $\sqrt[3]{\sqrt{g}}$
   F  $\sqrt[6]{g}$
   G  $\sqrt[3]{g}$
   H  $\sqrt[3]{g}$
   J  $\sqrt[3]{g}$

31. Rationalize the denominator of the expression.
   $\frac{\sqrt[3]{x^3}}{\sqrt[3]{3xy^3}}$
   A  $\frac{x\sqrt[3]{x}}{3y^2}$
   B  $3x^2y\sqrt[6]{x}$
   C  $\frac{3x^2\sqrt{xy}}{3xy^3}$
   D  $\frac{x^2\sqrt{3y}}{3y^2}$

32. Simplify.
   $-\sqrt[3]{2x^4y^2} \cdot 3\sqrt[3]{20x^5y}$
   F  $-24x^3y\sqrt[3]{5}$
   G  $-6x^3y\sqrt[3]{5}$
   H  $-6x^3y^3\sqrt[3]{5}$
   J  $-6x^3y\sqrt[3]{40}$

33. Simplify.
   $\frac{\frac{1}{x^2\sqrt{2}}}{x^{-1}}$
   A  $x$
   B  $x^3$
   C  $x^{-1}$
   D  $x^2$

34. Simplify.
   $5\sqrt{x} + 3\sqrt{y} - \sqrt{x}$
   F  $7\sqrt{xy}$
   G  $7\sqrt{x} + \sqrt{y}$
   H  $4\sqrt{x} + 3\sqrt{y}$
   J  $5 + 3\sqrt{y}$
35. Simplify.
\[ 9 \sqrt{45} + 2 \sqrt{20} \]
- A \( \sqrt{320} \)
- B \( 31 \sqrt{5} \)
- C \( 128 \sqrt{3} \)
- D 4805

36. Simplify.
\[ (5 + 2\sqrt{3})(2 - \sqrt{3}) \]
- F \( 5 + 4\sqrt{3} \)
- G \( 1 + 3\sqrt{3} \)
- H \( 3 - 2\sqrt{3} \)
- J \( 4 - \sqrt{3} \)

37. Which of the following is equal to \( c^{-\frac{1}{3}} \)?
- A \( \frac{1}{\sqrt[3]{c}} \)
- B \( -\sqrt[3]{c} \)
- C \( -c^3 \)
- D \( \frac{1}{c^3} \)

38. Which expression is equivalent to the expression \( \sqrt{x^2y^{-6}} \)?
- F \( xy \)
- G \( \frac{x^4}{|y^3|} \)
- H \( x^{16}y^{-12} \)
- J \( -x^4y^3 \)

39. Write the expression below using rational exponents.
\[ \sqrt[3]{x^2y^2} \]
- A \( x^{\frac{3}{2}}y^{\frac{1}{2}} \)
- B \( x^{\frac{4}{3}}y^{\frac{2}{3}} \)
- C \( x^{\frac{3}{2}}y^{\frac{6}{2}} \)
- D \( x^{12}y^8 \)

40. The graph of \( y = -x^2 - 2 \) is the solid graph below. Which dashed graph is its inverse?
- F \( a \)
- G \( b \)
- H \( c \)
- J none of the above

41. Which equation describes the inverse of \( f(x) = 7x + 8 \)?
- A \( f^{-1}(x) = -\frac{1}{7}x + \frac{8}{7} \)
- B \( f^{-1}(x) = \frac{1}{7}x - \frac{8}{7} \)
- C \( f^{-1}(x) = -\frac{1}{7}x - \frac{8}{7} \)
- D \( f^{-1}(x) = \frac{1}{7}x + \frac{8}{7} \)
# Common Core Readiness Assessment 2 Report

<table>
<thead>
<tr>
<th>Common Core State Standards</th>
<th>Test Items</th>
<th>Number Correct</th>
<th>Proficient? Yes or No</th>
<th>Mathematics III Lesson(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number and Quantity</strong></td>
<td></td>
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<tr>
<td>N.CN.9 (+) Know the Fundamental Theorem of Algebra; show that it is true for quadratic</td>
<td>7</td>
<td>4-7</td>
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<tr>
<td>polynomials.</td>
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<tr>
<td><strong>Algebra</strong></td>
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<tr>
<td>A.SSE.2 Use the structure of an expression to identify ways to rewrite it. For example,</td>
<td>2, 20,</td>
<td>4-2, 4-3, 4-4,</td>
<td></td>
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</tr>
<tr>
<td>see $x^4 - y^4$ as $(x^2 + y^2)^2 - (x^2 - y^2)^2$, thus recognizing it as a difference of</td>
<td>26-39</td>
<td>4-6, 4-7, 4-8,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>squares that can be factored as $(x^2 - y^2)(x^2 + y^2)$.</td>
<td></td>
<td>5-1, 5-2, 5-3,</td>
<td></td>
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<tr>
<td>A.APR.1 Understand that polynomials form a system analogous to the integers, namely, they</td>
<td>1</td>
<td>4-5</td>
<td></td>
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<tr>
<td>are closed under the operations of addition, subtraction, and multiplication; add, subtract,</td>
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<tr>
<td>and multiply polynomials.</td>
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<td>A.APR.2 Know and apply the Remainder Theorem: For a polynomial $p(x)$ and a number $a$, the</td>
<td>9</td>
<td>4-3, 4-6</td>
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<td>remainder on division by $x - a$ is $p(a)$, so $p(a) = 0$ if and only if $(x - a)$ is a</td>
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<td>factor of $p(x)$.</td>
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<td>A.APR.3 Identify zeros of polynomials when suitable factorizations are available, and use</td>
<td>3, 4, 5</td>
<td>5-2, 5-3</td>
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<td>the zeros to construct a rough graph of the function defined by the polynomial.</td>
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<td>A.APR.7 (+) Understand that rational expressions form a system analogous to the rational</td>
<td>15, 16, 17,</td>
<td>4-3, 4-9, 5-4,</td>
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<td>numbers, closed under addition, subtraction, multiplication, and division by a nonzero</td>
<td>18, 19</td>
<td>5-5, 5-6</td>
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<td>rational expression; add, subtract, multiply, and divide rational expressions.</td>
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<td>A.CED.2 Create equations in two or more variables to represent relationships between</td>
<td>12, 21, 22</td>
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<td>quantities; graph equations on coordinate axes with labels and scales.</td>
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<td>A.REI.2 Solve simple rational and radical equations in one variable, and give examples</td>
<td>23, 24, 25</td>
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<td>showing how extraneous solutions may arise.</td>
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<td>A.REI.11 Explain why the x-coordinates of the points where the graphs of the equations ( y = f(x) ) and ( y = g(x) ) intersect are the solutions of the equation ( f(x) = g(x) ); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where ( f(x) ) and/or ( g(x) ) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.</td>
<td>14</td>
<td>4-4, 5-7</td>
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**Functions**

| F.IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity. | 8 | 4-1, 4-3, 4-9, 5-4, 5-5, 5-6 | |
| F.IF.6 Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph. | 11 | 4-9 | |
| F.IF.7.e Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. | 6, 10 | 4-3, 4-9, 4-10 | |
| F.IF.7.d Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. | 13 | 5-6 | |
| F.BF.4.a Solve an equation of the form \( f(x) = c \) for a simple function \( f \) that has an inverse and write an expression for the inverse. For example, \( f(x) = 2^x \) for \( x > 0 \) or \( f(x) = (x + 1)/(x - 1) \) for \( x \neq 1 \). | 26, 41 | 6-7 | |
| F.BF.4.c(+) Read values of an inverse function from a graph or a table, given that the function has an inverse. | 40 | 6-7 | |
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